ON THE USE OF GEOMAGNETIC INDICES TO CHARACTERIZE THE THERMOSPHERE RESPONSE TO GEOMAGNETIC ACTIVITY FORCING

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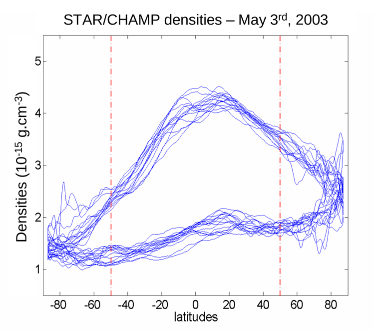
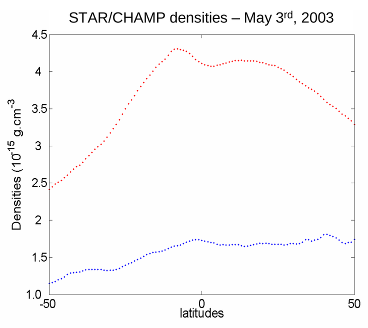
The data

STAR atmosphere density along CHAMP trajectory …

The orbit LT drift is of few minutes per 24 hours; during the same period, the altitude of the satellite varies by less than few hundreds of meters at given latitude.



… between -50° and 50° in latitude, with a 1° sampling period with respect to the latitude

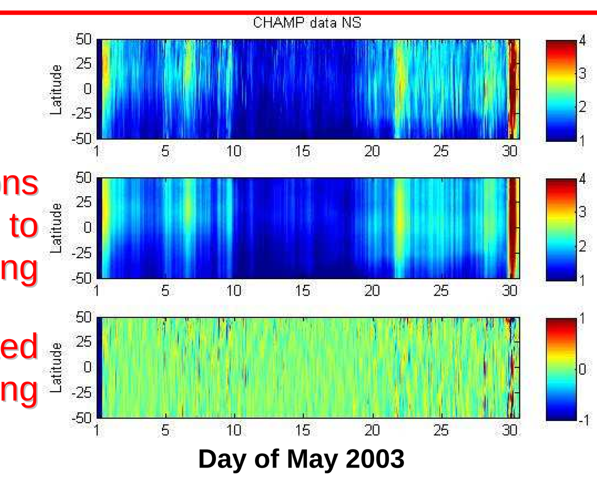


During periods of magnetic quietness, density variations along 50N–50S orbit segments are expected to be very similar during a 24-hour period.

daytime and night time orbit sections are considered separately

Altitude/latitude variations + planetary response to magnetic activity forcing

Gravity waves generated by Joule heating



CHAMP/STAR density estimates along the NS orbit segments, as a function of latitude and UT time during May 2003. Altitude and latitude variations are combined in this colour plot.

projection of the CHAMP/STAR density data on the first singular vector (i.e., $c_1 u_1$ variation)

residuals, i.e. differences between the CHAMP/STAR densities and their projection on the first singular vector.

LT at the satellite position varies from 5:40 am to 2:55 am. For the three panels, the density variations are displayed using the colour scale displayed on the right; they are expressed in terms of 10^{-12} kg.m^{-3} units.

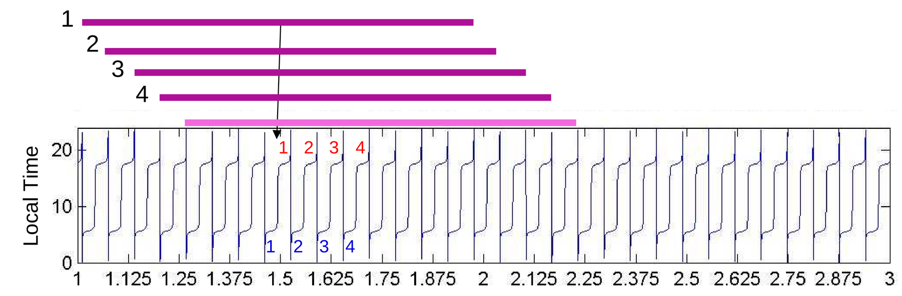
Separation according to spatial scale

Data analysis: running 15-orbit SVD analysis

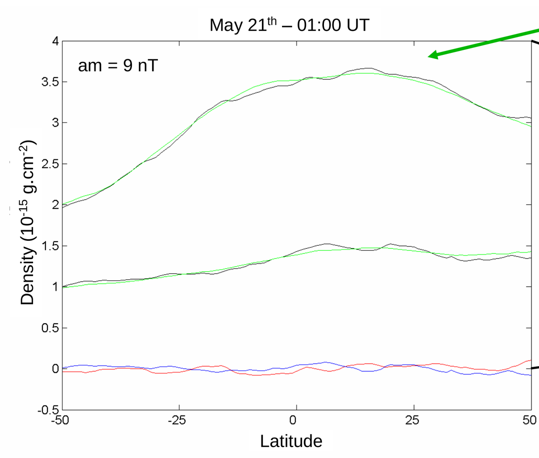
SVD analysis using a sliding window of 15 consecutive orbits.

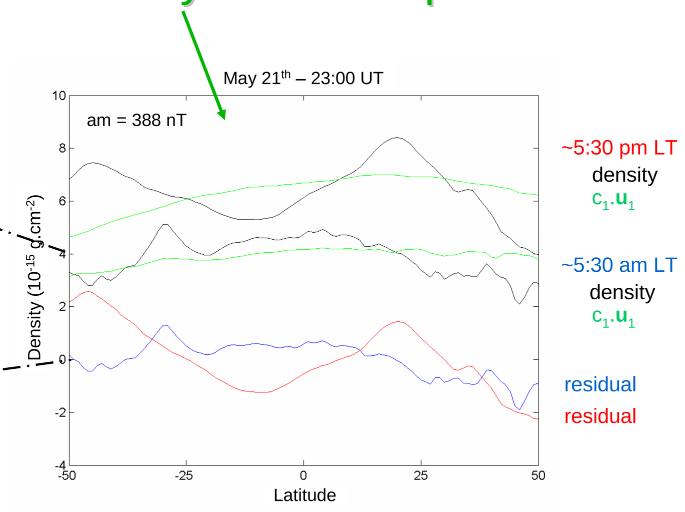
South-North and North-South bounds are considered separately.

The results are associated to the orbit #8; we only consider the first singular vector ($\mathbf{u}_1$) and the projection coefficient c_1 of the data on this vector.



Examples of results for orbits during magnetic quiet and very disturbed periods





Orbit during magnetic quietness:

- the projection on the first singular vector ($c_1\mathbf{u}_1$, green curve) accounts for almost the whole variance in the density variation (~99%);
- the intensity of the residual is negligible.

Orbit during very intense magnetic disturbance :

- the projection on the first singular vector ($c_1\mathbf{u}_1$, green curve) accounts for almost the whole variance in the density variation (~97%). its intensity is significantly larger than during magnetic quietness;
- the intensity of the residual is not negligible.

Results

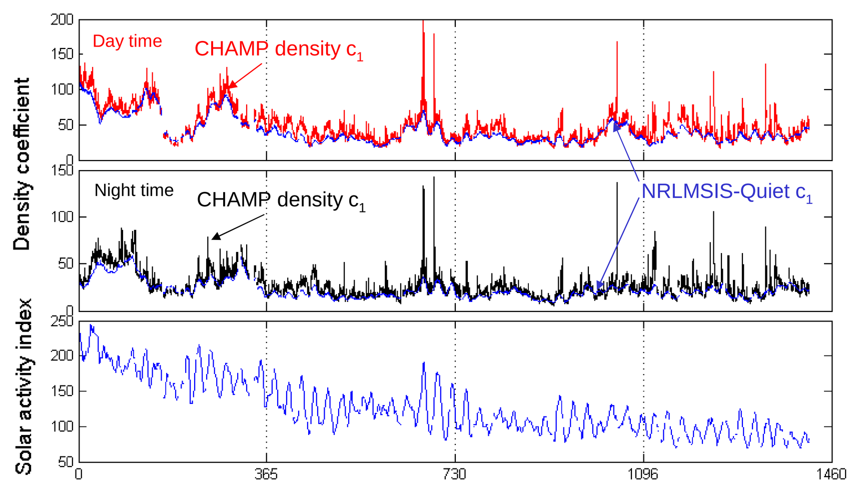
Time variation of large scale spatial variations

Time variations of the large scale spatial variations in the density are captured by the c_1 projection coefficient.

CHAMP density c_1 values are larger during day time than during night time

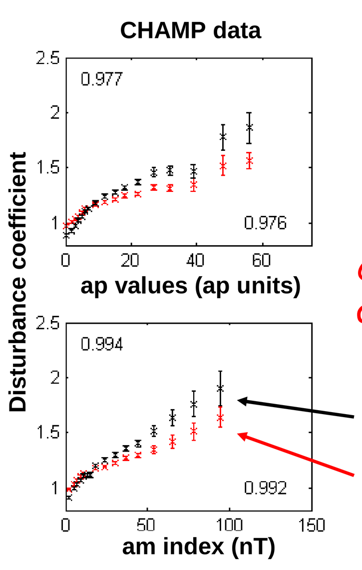
CHAMP density c_1 values are modulated by solar UV activity.

NRLMSIS-Quiet c_1 values are computed for the same situation, but without magnetic activity by means of NRLMSIS-00 model with ap set to 4



Years 2002 to 2005
day number from 2002, January 1st

Thermospheric forcing by geomagnetic activity



Binning of the CHAMP disturbance coefficients as a function of geomagnetic activity

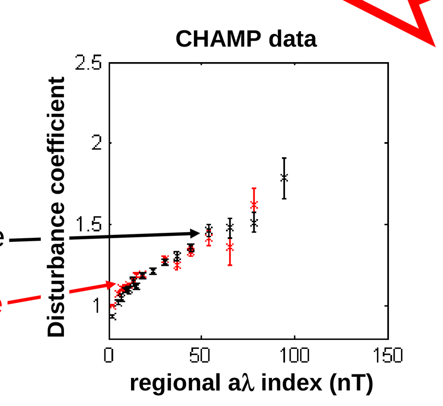
at the planetary scale

at the regional scale

c_1 is better correlated with am indices than with ap ones

Night-time

Day-time



Night-time

Day-time

day/night discrepancy disappears when using regional indices

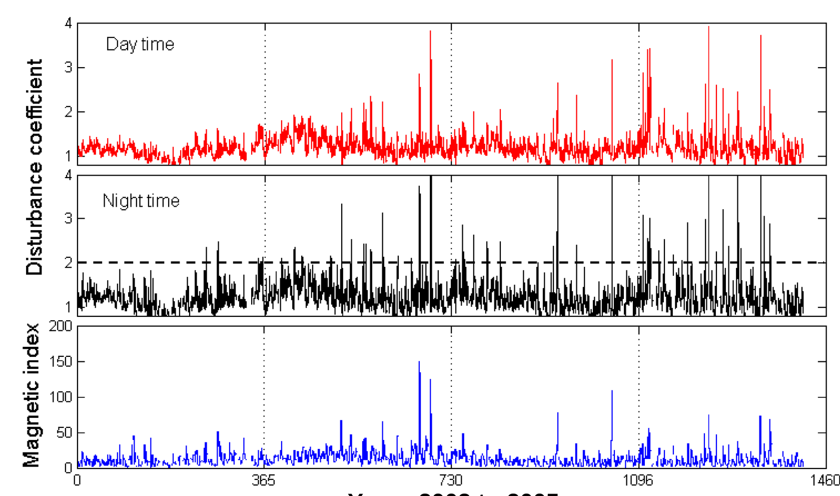
Indices correspond to the 3-hour interval before the ongoing one

Disturbance coefficient: CHAMP density c_1 coefficient divided by the corresponding NRLMSIS-Quiet c_1 coefficient

Event selection

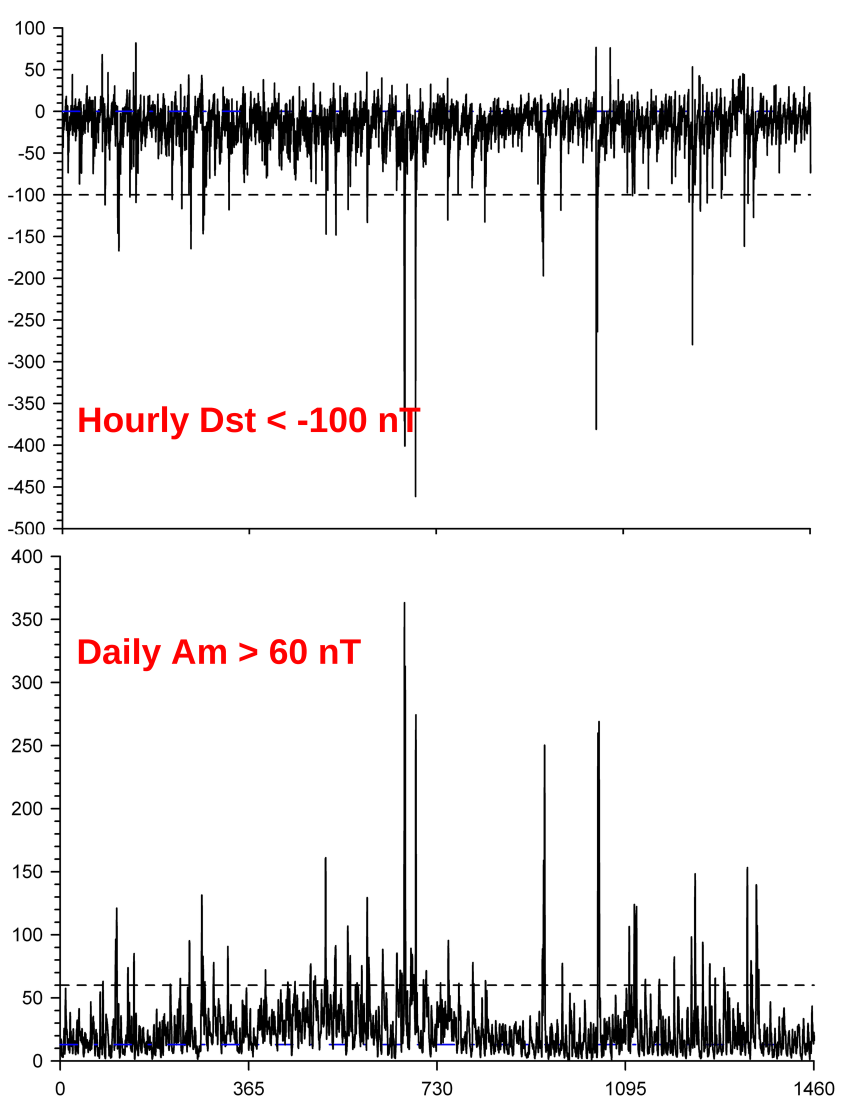
Either from thermosphere density variations as monitored by the disturbance coefficients…

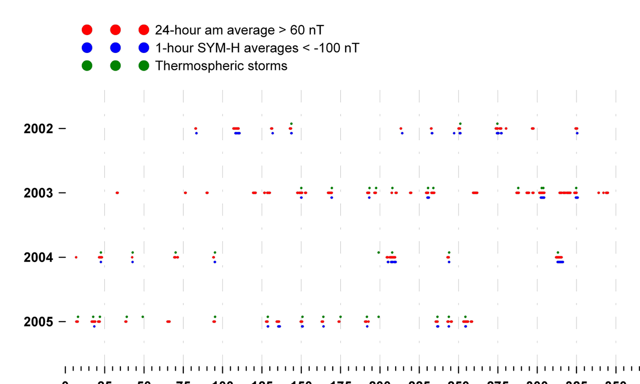
"Thermospheric storm": Night time disturbance coefficient >2



Years 2002 to 2005
day number from 2002, January 1st

… or from intense magnetic storms as deduced from Dst indices…



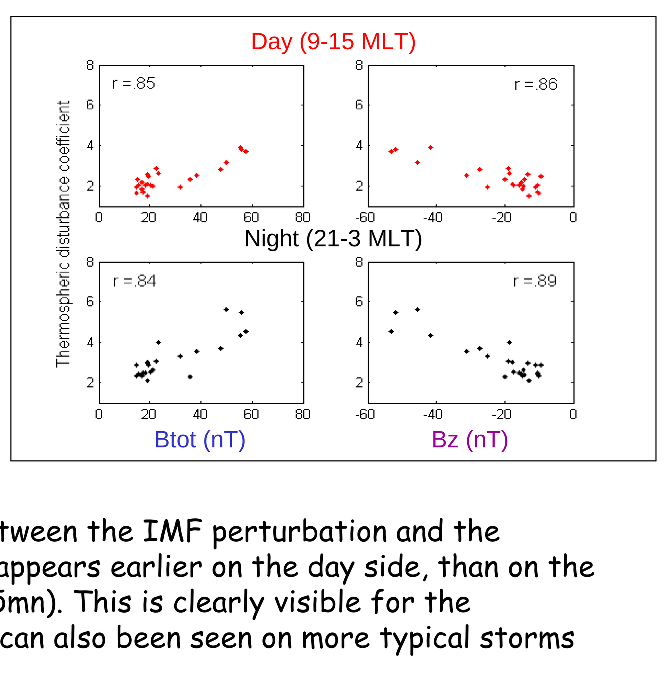


During the 2002-2005 time period, "Thermospheric storm" are well correlated to intense magnetic storms after mid 2003. In 2002, when solar activity is high, intense magnetic storms may not result in significant thermospheric storms.

Thermospheric storms and solar wind conditions

The most salient feature is the very large variability in the observed variations of IMF and solar wind parameters which drive the thermospheric storms. Although small IMF perturbations may result in significant thermospheric perturbations (e.g. 2004, July 17th, or 2005, April 5th), there is however a good correlation between the thermospheric disturbance and IMF Btot and Bz.

Correlation between the maximum values of the disturbance coefficient and those of Btot and Bz, for the 24 thermospheric storms of 2003-2004-2005, observed in the 9-15 and 21-3 MLT sectors



Another observed feature is the variable delay between the IMF perturbation and the thermospheric disturbance which however usually appears earlier on the day side, than on the night side (mean delay of respectively 5h and 6h45mn). This is clearly visible for the superstorms of October and November 2003, but can also been seen on more typical storms (e.g., 2005, January 8th and 22th).